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INDIAN OCEAN PROJECT

MEASUREMENTS OF CURRENTS ALONG THE EQUATOR IN THE INDIAN OCEAN

by

John A. Knauss and Bruce A. Taft

KINGSTON, RHODE ISLAND

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GRADUATE SCHOOL OF OCEANOGRAPHY
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University of Rhode Island
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Measurements of Currents along the Equator in the Indian Ocean

IN recent years large, high-speed, eastward flows beneath the surface along the equator have been discovered and/or rediscovered[1]. The structure of the Cromwell Current in the central and eastern Pacific has been described in some detail[2]. The current is symmetrical about the equator, has a transport as great as 40×10^6 m^3/sec and has a maximum speed in the thermocline of about three knots. The current appears to be steady and to be in geostrophic balance to within a half a degree of the equator. The distributions of oxygen, salinity and other properties indicate upwelling of water along the equator and strong vertical mixing. The observations in the Atlantic Ocean indicate that the current structure there is remarkably similar[3].

Although it is generally believed that these undercurrents are in some way related to the overlying wind field, the driving mechanism and method of maintenance of these currents are still not certain. For this reason an investigation of the equatorial circulation in the Indian Ocean during different monsoon conditions is part of the programme of the International Indian Ocean Expedition. The first part of this expedition has been completed. During June 28–September 24, 1962, *Argo* of the Scripps Institution of Oceanography, University of California, occupied a zonal line of stations along the equator and four cross-sections from 5° N. to 5° S. (Fig. 1). Ninety-seven hydrographic stations and twenty-one current-measuring stations were occupied. Some ninety velocity soundings were made at these twenty-one stations. The current-measurement technique was similar to that previously described.

During the period of observation there was no strong eastward, subsurface flow similar to that found in the other two oceans. Maximum speeds were not necessarily found at the equator. The maximum speeds at a given position were associated with the top of the thermocline and ranged from one to two knots. On the average, higher current speeds were found in the western than in the eastern Indian Ocean. In many instances the north-south component of velocity exceeded the east-west component.

The most characteristic feature of the three months of measurements was the variability of the flow. Although the current structure at a given location remained constant over a 24-h period, it did not remain constant over periods

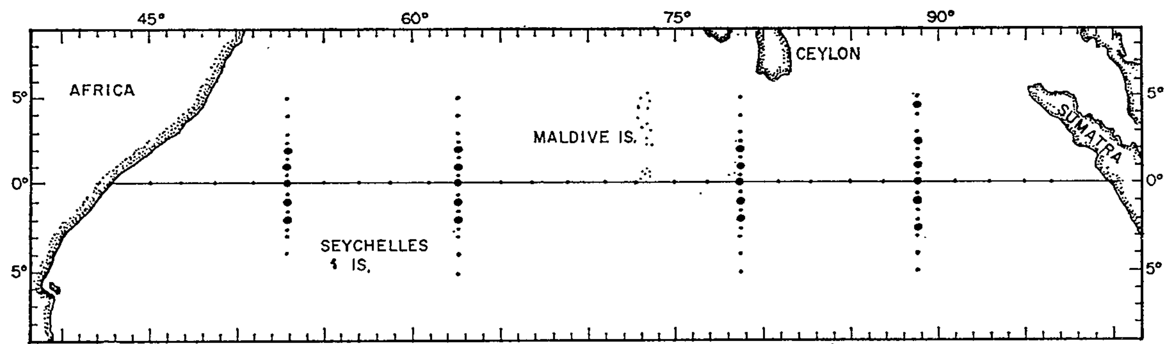

Fig. 1. Station pattern for *Argo*, June 27–September 24, 1962. Small dots indicate hydrographic stations; large dots current meter and hydrographic stations

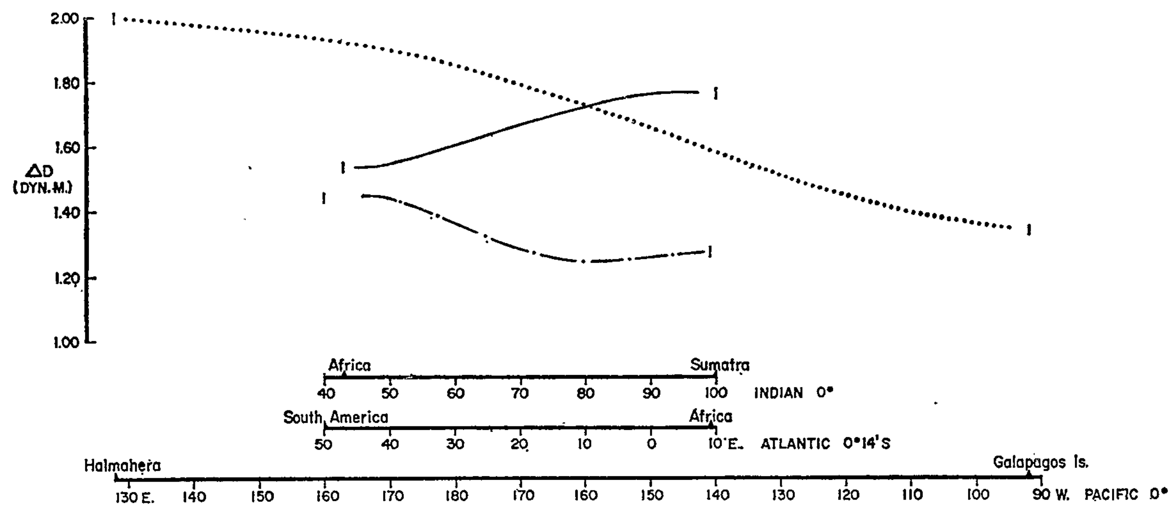

Fig. 2. Dynamic topography of the sea surface (surface referred to 1,000 decibars). Solid line is the Indian Ocean based on *Argo* data; dash-dot line is the Atlantic based on *Crawford* cruise, November 1958; dotted line is a composite of all available Pacific data

of three weeks, and on some occasions was not steady over periods of 3–5 days. This is in marked contrast to the observations in at least the central and eastern Pacific.

Preliminary indications are that the observed current was not in geostrophic balance. In one of the four cross-sections (53° E.) this was obviously the case. The north–south pressure gradient force from 2° N. to 1° S. based on seven hydrographic stations was 5×10^{-4} dyne/g. The gradient appeared to be constant and did not reverse itself at the equator. A zonal geostrophic current of 200 cm/sec (3·9 knots) at 1° N. would be necessary to balance such a pressure gradient force—a current 10 times greater than what was observed.

There was no evidence of upwelling, 'spreading of the thermocline' or vertical mixing of the water at the equator, all features which are associated with the equatorial undercurrents in the Atlantic and the Pacific.

One of the reasons for looking at the equatorial circulation in the Indian Ocean was the indication that the east–west pressure gradient in this ocean was different from that found in the Atlantic and the Pacific. In the Atlantic and Pacific the sea surface slopes down to the east along the equator. Although the magnitude of the slope varies with longitude and probably with time, there is no evidence that it changes sign. During the three-month period we were in the Indian Ocean the gradient was constant, of approximately the same magnitude as that in the Atlantic and Pacific, but of opposite sign (Fig. 2). It seems reasonable to assume that the marked difference in the current structure between the Indian Ocean and that observed in the Atlantic and Pacific is related to the change in sign of the pressure gradient. The east–west pressure gradient may be different during the other monsoon season. We expect to make further observations during the period February 15–May 15, 1963.

This work reported was part of the Lusiad Expedition—a joint University of California, University of Rhode Island venture, and a United States contribution to the International Indian Ocean Expedition. Support for the work was provided by the Office of Naval Research and the National Science Foundation.

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